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THE HYDROLOGY OF LAKE QARUN, FAYOUM PROVINCE, EGYPT. PART II: THE SUCCESSIVE INCREASE OF SALINITY IN THE LAKE QARUM.

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ABSTRACT

Lake Qarun is a closed basin that lies within Fayoum Province, Egypt. It was a fresh water reservoir used for irregation purposes in the ancient times. Its salinity (defined here as grammes of dissolved salts per liter) has been increasing during the present centuary from about 11.0 gm/l in 1906 to more than 31.0‰ in 1982. Although the salinity of the Lake is fluctuating around the value 30.0‰, the total salt content in its water undergoes a progressive increase with time. The best fit curve relating the total salt content with time is a straight line with a slope of 0.101. The rate of increase of the total salt content is expected to remain constant during the period (1982-2050), while the mean salinity of the Lake may show a progressive increase with time, which inturn must lead to a change in the Lake bottom fauna and consequently its fisheries.

INTRODUCTION

Lake Qarun was considered in the past as a reservoir of fresh water of the River Nile during the flooding season and was discharged during drought time. Its level was about 5 - 20 m above the mean sea level at Alexandria, and its salinity was always less than 1.0 gm/l. Later, dams have been constructed across the streams where the water supply from the River Nile to the depression is being partially controlled and water quantities entering the Fayoum Province have been restricted and the water level in the Lake started to decrease. Consequently, the lands have been cultivated and the excess water has passed into the Lake through drainage processes. During the flooding season, the land was submerged by the Nile water and both the Lake and the surrounding lands stood at the same level, and hence most of the Lake water might have left the Lake by outward percolation into the marshy tracts of the surrounding desert causing a continuous reduction of the Lake salinity.

With time, the salinity of the Lake started to increase due to conveying dissolved salts into the Lake and the excessive evaporation attained at the surface particularly during summer.

MATERIAL AND METHODS

In order to follow the increase of salinity of the Lake water during the period 1906 - 1982, Table 1 is compiled to include most of the available information as collected from the literatures as well as the observations obtained by the writer during the period 1981 - 1982. To estimate the total salt content in the Lake, the amount of water existing in the Lake according to its level is determined at first using formula "2" shown below. The result is then multiplied by the salinity to get the total salt content (in million tons). The salinity (in gm/l) is then corrected using the density of the water at each location to get the corrected salinity.

Area and Volume of The Lake and Their Relationship to Salt Content:

Since the water level varies greatly seasonally as well as annually, hence the estimation of the total salt content in the Lake water may be complicated. Ball (1939) established two emperical formulae as a function of depth to calculate the areas (A) in 10^6 m^2 and volumes (V) in 10^6 m^3 of the Lake at different levels (L) in meter below the sea level:

$$A = 166 + 24\ (47 - L) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$V = 422 + 166\ (47 - L) + 12\ (47 - L)^2 \quad \ldots (2)$$

By using the above formulae, the total amount of salt content in the Lake can be deduced at any time of the year. If the rate of increase of salinity can be accurately determined, the salinity of the Lake may be easily predicted for the years with certain assumptions concerning the change in water volume. This will help greatly to understand the exact ecological situation of the Lake, and how far it could be improved for fish production.

DISCUSSION

In 1885, the Lake level was recorded accurately for the first time when a level of 40.38 m below the mean sea surface was recorded, while in 1891 the level was -43.24 m. From that time to the present, the level was never higher than -43.0 m as the maximum level attained during this period was -43.19 m in 1981.

During the period (1885 - 1982) a continuous supply of dissolved salts was conveyed into the Lake by the drains. Although the drainage water flows annually into the Lake, the salinity of the Lake water shows a great variability not only on seasonal basis but also from year to year (Table 1).

Actually, the salinity or salt content (mg/l) varies greatly from one part to another and over the different regions of these parts particularly near the outlets of the

Table (1)

A review of the water level (m); volume of water ($10^6 m^3$); the total salt content (in gm/l); the total salt content (in 10^6Tons); and the corrected salinity in Lake Qarun in January, July, October and the annual mean value during the period 1906-1982.

Year	JANUARY					APRIL					JULY				
	Lake level (m)	Volume of water $10^6 m^3$	Total salt cont. gm/l	Total salt cont. 10^6Ton	Corr. Salinity	Lake level (m)	Volume of water $10^6 m^3$	Total salt cont. gm/l	Total salt cont. 10^6Ton	Corr. Salinity	Lake level (m)	Volume of water $10^6 m^3$	Total salt cont. gm/l	Total salt cont. 10^6Ton	Corr. Salinity
1906	-44.31	955	11.0	10.5	--	-44.28	963	11.2	10.8	--	--	--	--	--	--
1919	-44.60	890	16.2	14.4	--	-44.63	883	17.0	15.2	--	-44.94	815	20.2	16.5	--
1920	-44.34	903	16.9	15.3	--	-44.31	956	16.1	15.4	--	-44.68	870	18.0	15.7	--
1921	-44.67	875	18.1	15.8	--	-44.64	881	18.0	15.8	--	-45.2	748	17.9	14.3	--
1922	-44.89	826	19.7	16.3	--	-44.84	837	20.0	16.7	--	-45.33	733	23.2	17.0	--
1924	--	--	--	--	--	--	--	--	--	--	-45.51	696	23.1	15.4	--
1925	-44.90	824	19.3	15.9	--	-44.79	848	20.8	17.6	--	-45.15	770	23.3	17.9	--
1926	-44.90	824	22.0	18.1	--	-44.70	868	20.3	17.6	--	-45.09	787	23.6	18.6	--
1927	-44.73	864	21.2	18.3	--	-44.62	886	20.8	18.4	--	-45.03	796	23.0	18.3	--
1928	-44.82	842	22.0	18.5	21.66	-44.82	842	21.2	17.9	20.92	-45.28	743	26.0	19.3	25.60
1929	-45.03	796	24.1	19.2	23.70	-45.00	802	23.9	19.2	23.50	-45.46	706	24.5	18.1	24.10
1930	-44.96	810	23.9	19.4	23.50	-44.87	830	21.8	18.1	21.50	-45.32	735	25.1	18.4	24.7
1931	-45.04	794	26.0	19.7	25.50	-44.98	806	23.4	18.9	23.10	-45.48	702	29.8	20.9	29.30
1932	-45.44	711	29.3	20.8	28.70	-45.43	713	28.6	20.4	28.00	-45.94	611	34.4	21.0	33.70
1933	-45.56	686	25.3	17.3	25.10	-45.53	692	30.2	18.7	29.60	-46.04	592	38.0	22.5	37.10
1934	-45.37	725	23.7	19.6	25.30	-45.22	752	29.8	22.4	29.20	-45.64	670	33.7	22.6	33.00
1935	-44.97	809	25.8	20.9	25.30	-44.83	842	25.7	21.6	25.30	-45.18	764	29.4	22.5	28.80
1954	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1958	--	--	--	--	--	--	--	--	--	--	--	--	--	--	28.30
1959	--	--	24.3	--	23.90	--	--	24.8	--	24.50	--	--	--	--	--
1970	-43.82	1071	--	--	--	-43.78	1080	--	--	--	-43.94	1042	--	--	32.50
1974	--	--	--	--	28.30	--	--	--	--	30.30	--	--	--	--	31.90
1975	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1978	-43.85	1064	--	--	--	-43.75	1088	--	--	--	-44.13	997	38.9	38.0	38.00
1979	-43.70	1100	32.5	35.7	31.70	-43.57	1133	31.7	34.8	31.00	-43.79	1078	32.5	35.1	31.90
1980	-43.37	1183	29.7	35.1	29.00	-43.25	1213	30.5	36.9	29.90	-43.59	1128	--	--	--
1981	-43.40	1175	32.2	37.8	31.40	-43.21	1223	30.3	37.1	29.70	-43.55	1138	32.8	37.4	32.20
1982	-43.51	1148	27.8	32.0	27.30	-43.46	1160	33.0	38.3	32.30	-43.77	1083	33.2	36.0	32.50

Table (1) continued

Year	OCTOBER Lake level (m)	Volume of water $10^6 m^3$	Total salt cont. gm/l	Total salt cont. 10^6Ton	Corr. Salinity	MAY Lake level (m)	Volume of water $10^6 m^3$	Total salt cont. gm/l	Total salt cont. 10^6Ton	Corr. Salinity	REFERENCES
1906	--	--	--	--	--	-44.30	939	14.1	10.5	11.0	Lucas (1906)
1919	-45.16	764	20.1	15.4	--	-44.86	852	18.4	15.4	18.1	Ball (1939)
1920	-44.96	811	19.3	15.7	--	-44.62	885	17.6	15.7	17.4	Ball (1939)
1921	-45.36	727	22.8	16.6	--	-45.00	802	19.2	15.6	18.9	" "
1922	-45.65	668	23.3	14.9	--	-45.25	749	21.6	16.2	21.2	" "
1924	-45.74	650	24.3	15.8	--	--	--	--	15.6	--	" "
1925	--	--	--	--	--	-45.10	781	23.4	17.1	23.0	" "
1926	-45.16	773	23.8	18.4	--	-44.99	804	22.4	18.2	22.0	" "
1927	-45.19	764	24.2	18.5	--	-44.95	813	22.3	18.4	21.9	" "
1928	-45.43	713	28.3	20.2	27.80	-45.10	781	24.4	18.9	24.0	" "
1929	-45.47	704	26.1	18.4	25.70	-45.23	754	24.6	18.8	24.3	" "
1930	-45.44	711	25.3	18.6	25.00	-45.15	771	25.5	18.6	25.2	" "
1931	-45.76	646	30.3	19.6	29.70	-45.37	725	27.4	19.8	26.9	" "
1932	-46.14	573	34.1	19.5	33.40	-45.77	644	31.6	20.4	31.0	" "
1933	-46.07	587	30.3	17.8	29.80	-45.79	640	31.0	19.1	30.4	Ball(1939)&Faouzi(1935)
1934	-45.61	676	23.2	15.7	23.20	-45.42	713	27.6	20.1	27.1	Ball(1939)
1935	-45.24	750	31.2	23.4	30.50	-45.02	798	28.0	22.1	27.5	Ball(1939 &Faouzi(1935)
1954	--	--	--	--	--	-44.60	890	29.0	25.8	30.1	Naguib (1958)
1958	--	--	--	--	26.40	-44.22	976	--	--	--	El-Sarka (1961)
1959	--	--	--	--	--	-44.22	976	--	--	--	El-Sarka (1961)
1970	-44.04	1018	--	--	33.50	-43.75	1088	30.6	33.2	31.7	Mashal (1973)
1974	--	--	--	--	30.40	--	--	--	--	28.1	Dowidar (1982)
1975	--	--	--	--	34.90	--	--	--	--	--	Iwhak & Abd-El-Malek(1980)
1978	-44.29	960	42.9	41.2	41.80	-43.90	1052	36.6	37.9	35.9	Anon. (1978)
1979	-43.89	1054	35.6	37.5	34.80	-43.72	1095	33.1	35.8	32.4	Anon. (1980)
1980	-43.79	1078	35.5	38.3	34.70	-43.50	1150	31.9	36.8	31.2	Anon. (1981)
1981	-43.80	1076	35.3	38.0	34.50	-43.50	1130	32.7	37.9	32.0	Anon. (1981)
1982	-44.00	1028	33.8	34.8	33.10	-43.70	1100	33.3	36.3	32.5	Anon. (1984)

drains where the lowest salinity values can be observed and in the extreme western regions of the western part where the highest salinity often existed. Moreover, the salinity at the surface is nearly everywhere less than that near the bottom. Therefore, the locations and the seasons at which samples were collected may be considered as the main parameters expressing such fluctuations in the salinity values.

Few investigators suggested that the methodology of analysing the samples is responsible for the fluctuations that occur in the salinity values. Others attributed these fluctuations to other factors, such as: evaporation and the process of estimating it, and water seepage from and into the Lake. Meshal (1973) has corrected these values through the period 1906 - 1956, however the new values still show some fluctuations. The seasonal variations of salinity (gm/l), total salt content (in 10^6 tons) and water level (expressed as the seasonal variations in the volume of water exists in the Lake) during the period 1906 - 1982 are given in Table 2, which shows the following:

a- Salinity indicates mostly negative seasonal variation when the water level rises (volume of water increases) due to the influx of fresh water from drains, and positive variation when the water level falls (volume of water decreases or when evaporation exceeds discharged water from drains). However, the decrease or increase of salinity are not conformable with the rise and fall of the water level due to the imperfection of sampling.

b- The total salt content nearly shows similar trend as that of salinity when the seasonal variations of salinity are greater than zero. Since the Lake is a closed region, and no water is moving in or out-ward through percolation, then the total salt content is expected to increase with time. Therefore, the negative as well as the high variations of the total salt content, which may be attributed either to the imperfection of sampling or to the incorrect estimation of the average salinity from a highly stratified water, are insignificant and can not be considered as representative values for the whole Lake.

Therefore, it is preferable to consider the small positive variations and particularly a set of successive small positive variations of the total salt content when dealing with the successive increase of salt content.

Generally, the annual average rates of evaporation and precipitation are almost constant (the changes that occur in the Lake surface area are minimal), while the seasonal and annual drainage waters discharging into the Lake (volume of the water in the Lake) show clear fluctuations. Accordingly, it may be suggested that the seasonal total content (million of tons) traces the hydrographic variability of the Lake.

Table (2)

Seasonal variations of salinity, total salt content and water level during the period 1906-1982.

YEAR	Salinity Variations (gm/l)				Lake Water Level Variations($10^6 m^3$)				Total Salt Content Variations(10^6Tons)			
	Apr.-Jan.	July-Apr.	Oct.-July	Jan.-Oct.	Apr.-Jan.	July-Apr.	Oct.-July	Jan.-Oct.	Apr.-Jan.	July-Apr.	Oct.-July	Jan.-Oct.
1906	0.2	- -	- -	- -	8	- -	- -	- -	0.3	- -	- -	- -
1919	0.8	3.2	- 0.1	- 3.2	- 7	- 68	- 51	139	0.8	1.3	- 1.1	- 0.1
1920	- 0.8	1.9	1.3	- 1.2	53	- 86	- 59	64	0.1	0.3	0.0	0.1
1921	- 0.1	- 0.1	4.9	- 3.1	6	- 133	- 21	99	0.0	- 1.5	2.3	- 0.3
1922	0.3	3.2	0.1	- -	11	- 104	- 65	- -	0.4	0.3	- 2.1	- -
1924	- -	- -	1.2	- 5.0	- -	- -	- 46	174	- -	- -	- 0.4	- -
1925	1.5	2.5	- -	- -	24	- 148	- -	- -	1.7	- 0.3	- -	- -
1926	- 1.7	3.3	0.2	- 2.6	44	- 81	- 14	91	- 0.5	1.0	- 0.2	- 0.1
1927	- 0.4	2.2	1.2	- 2.2	22	- 90	- 32	78	0.1	- 0.1	0.2	- -
1928	- 0.8	4.8	2.3	- 4.2	00	- 99	- 30	83	- 0.6	1.4	0.9	- 1.0
1929	- 0.2	0.6	1.6	- 2.2	6	- 96	- 2	106	0.0	- 1.1	0.3	1.0
1930	- 2.1	3.3	- 1.8	2.7	20	- 95	- 24	85	- 1.3	0.3	- 1.8	3.1
1931	- 2.6	6.4	0.5	- 1.0	12	- 104	- 56	65	- 0.8	2.0	- 1.3	1.2
1932	- 0.7	5.8	- 0.3	- 8.6	2	- 102	- 38	113	- 0.4	0.6	- 1.5	- 2.0
1933	4.2	7.2	- 7.7	- 6.6	6	- 100	- 5	138	1.2	3.8	- 4.7	- 1.8
1934	6.1	3.9	-10.5	2.6	27	- 82	6	133	2.8	0.2	- 6.9	5.2
1935	- 0.1	3.7	1.8	- -	33	- 78	- 14	- -	0.7	0.9	0.9	- -
1954	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1958	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1959	0.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1970	- -	- -	- -	- -	9	- 38	- 24	- -	- -	- -	- -	- -
1974	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1975	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1978	- -	- -	4.0	-10.4	24	91	- 37	140	- -	- -	3.2	- 5.5
1979	- 0.8	0.8	3.1	- 5.9	33	- 55	- 24	129	- 0.9	0.3	2.4	- 2.4
1980	0.8	- -	- -	- 3.3	30	- 85	- 50	97	0.8	- -	- -	- 0.5
1981	- 1.9	2.5	2.5	- 7.5	48	- 85	- 62	77	- 0.7	0.3	0.6	- 6.0
1982	5.2	0.2	0.6	- -	12	- 77	- 55	- -	6.3	- 2.3	- 1.2	- -

To trace the seasonal and annual variations in salinity as well as in total salt content, it is required to inspect critically the reported values given in Table 1.

In February 1906, five samples were collected from the surface and near the bottom in the central part of the Lake and showed an average salinity of 10.65 and 11.26 gm/l at surface and near the bottom respectively with an average of 11.0 gm/l (Lucas, 1906). In March 1906, samples from 36 locations, well distributed in the Lake, were collected at 1.5 m depth. The range of salinity variations was comparatively small (maximum salinity of 12.16 and minimum of 9.9 gm/l). The eastern and western parts had an average salinity of 10.6 gm/l and 11.7 gm/l respectively, while it showed an average of 10.9 gm/l along a line separating the two parts. The average salinity of the whole Lake was 11.17 gm/l. This value can be taken as a good base for the average salinity and accordingly the total salt content in the Lake at that time (Ball, 1939).

During the period 1918 - 1933, six samples were collected regularly at quarterly intervals from six locations situated nearly on a line extended from west to east along the middle of the Lake. The average values as reported by Ball (1939) are given in Table 1.

During the period (December 1928, January and March 1929 and September 1930), samples were collected from a large number of locations (25 - 36 points) from the surface and near the bottom showing mean salinities of 24.3, 24.4, 22.7 and 29.1 gm/l respectively (the maximum salinity values were 27.8, 25.6, 25.0 and 31.5 mg/l while the minimum values were 20.3, 23.0, 9.5 and 19.5 gm/l respectively). There are wide variations between the corresponding maximum and minimum salinity values except in January 1929 where the range was 2.6 gm/l (Azidian and Hug, 1929). The salinity of the Lake (24.4 gm/l) and hence the total salt content (19.4×10^6 tons) can be taken as representative values of the Lake at that time.

In 1931, 63 samples were collected at a fixed point for different monthes, the salinity varied between 27.0 gm/l in May and 34.4 gm/l in August (Abu-Samra, 1936).

During the period 1953-1955, water samples were collected from 13 locations mostly covered the Lake showing an average salinity of 30.6‰ (Naguib, 1959). In 1958-1959, water samples were collected from two locations in the Lake, one in the wastern part showing a salinity range of 22.4-29.36‰ with an average value of 26.0‰ and the other in the eastern part with salinity range of 19.6-29.43‰ with average of 24.8‰ (El-Zarka, 1961). In 1961-1962, samples were taken at a single location showing an average salinity of 24.4‰ (El-Zarka and El-Serafi, 1970). Again, these values are not representative for the whole Lake.

Samples during 1970 were collected monthly at different depths from 22 loactions well distributed in the Lake, showing an average salinity of 32.8‰ in the eastern part and 38.8‰ in the western part with an average 33.3‰ (Meshal, 1973). In 1974-1975, water samples were collected from the surface showing maximum of 34.59‰ and 34.90‰ in September 1974 and September 1975 respectively and minimum of 25.5‰ and 26.5‰ in December 1974 and December 1975 respectively. In 1974 also, samples were collected from the Lake showing a mean salinity value of 28.1‰.

During the period 1978-1982, water samples were collected from 11 locations distributed to cover mostly the Lake. Although the locations were fixed in the last period, the fluctuations in salinity and total salt content values still existed. Therefore, it is concluded that, as long as there exists salinity gradients in the horizontal and the vertical directions, the average salinity as well as total salt content often suffer inherent uncertainities on estimating their values and hence would show continuous fluctuation in space and time.

Generally, the total salt content in the Lake undergoes a progressive increase, while the salinity shows a peculiar phenomena where it fluctuates up and down around the salinity value of 30.0‰ during the last few years. These fluctuations are in fact owing to the continuous dilution of the Lake water with the fresh water supplied for irrigation. At present, the Lake water stands nearly at a fixed level of about -43.5 m. Accordingly, the Lake will show during the next few years a progressive increase for both salinity and total salt content.

Estimation of an Emperical Relation to Predict The Salinity Values For The Next Few Years:

The available data (Table 1) that were obtained during the period 1906-1982 is represented graphically in Figure 1. In addition, an emperical relation for the time changes of total salt content (in million tons) is estimated from which the expected values during the period 1985-2050 are estimated. By taking 1906 as the starting point for calculation with a period of a quarterly year as the successive increase of time variable, the emperical formula relating the total salt content to time, corresponding to the best fit linear relation, is given as:

$$Y = 0.101\ X + 8.655 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where: Y is the predicted total salt content (in million tons).

X is the quarterly-year periods starting from January 1906.

The predicted salt content in the Lake water for the next

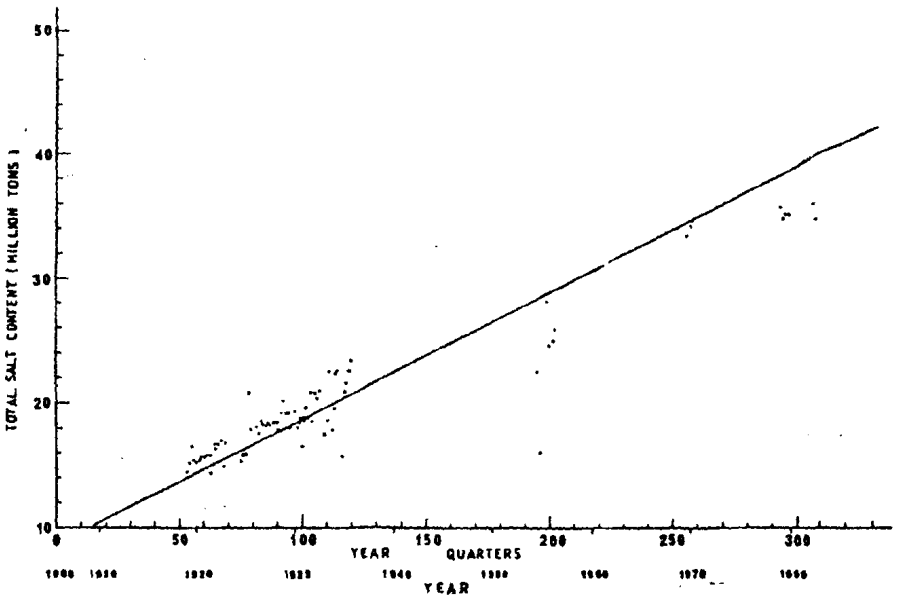

Fig. (1)
The total salt content (in million Tons) for quarterly-year during the period 1906-1982.
a- The available data as obtained from literatures
b- The best fit linear relation.

decades applying equation (3) is given in Table 3. The salt content (in gm/l) and the salinity of the Lake water are calculated using the following relations:

The salt content (in gm/l) =

$$\frac{\text{total salt content (in million tons)}}{\text{volume of water (in million cubic meters)}} \times 10^3 \quad \ldots (4)$$

Salinity = salt content (in gm/l) /density of water.. (5)

Table 4 gives the estimated salt content (in gm/l at different levels of the Lake water, while Table 5 gives an example of the estimated salinity at the water level of-43.5 m and mean water temperature of 20·0°C.

Table(3)
Predicted estimation of the total salt content in Lake Qarun during the period 1985-2050(in million tons).

Year	Period of Quarterly Years X	Total Salt Content Y
1985	320	40.975
1990	340	42.995
1995	360	45.015
2000	380	47.035
2005	400	49.055
2010	420	51.075
2015	440	53.095
2020	460	55.115
2025	480	57.135
2030	500	59.155
2035	520	61.175
2040	540	63.195
2045	560	65.215
2050	580	67.235

Table(4)
Predicted estimation of the total salt content in Lake Qarun during the period 1985-2050(in gm/l) at different water levels.

YEAR	LAKE LEVEL (m)					
	-43.50	-43.75	-44.00	-44.25	-44.50	-45.00
1985	35.63	37.65	39.86	42.27	44.93	51.09
1990	37.39	39.51	41.82	44.36	47.14	53.61
1995	39.14	41.36	43.79	46.44	49.36	56.13
2000	40.90	43.22	45.75	48.53	51.57	58.65
2005	42.66	45.08	47.72	50.61	53.79	61.17
2010	44.41	46.93	49.68	52.70	56.00	63.68
2015	46.17	48.79	51.65	54.78	58.22	66.20
2020	47.93	50.64	53.61	56.86	60.43	68.72
2025	49.68	52.50	55.58	58.95	62.65	71.24
2030	51.44	54.36	57.54	61.03	64.86	73.76
2035	53.20	56.21	59.51	63.12	67.08	76.28
2040	54.95	58.07	61.47	65.20	69.29	78.80
2045	56.71	59.92	63.44	67.28	71.51	81.31
2050	58.47	61.78	65.41	69.37	73.72	83.83

From Tables 3-5, it is expected that the Lake may show a progressive increase of salinity in the next few decades (as the water in the Lake stands at a fixed level and hence its volume remains constant), unless some processes may be considered to prevent the conversion of the Lake into a dead water body particularly its western part.

Table (5)
Predicted estimation of the total salt content in Lake Qarun during the period 1985-2050 at the water level -43.5 m and mean water temperature 20.0 °C.

Year	Salinity
1985	34.77
1990	36.44
1995	38.09
2000	39.77
2005	41.42
2010	43.06
2015	44.71
2020	46.36
2025	47.99
2030	49.62
2035	51.25
2040	52.87
2045	54.48
2050	56.09

The observations obtained during 1988 showed an average salinity of about 35.0‰ (Personal communication), which agrees well with the expected value estimated through the present study.

SUMMARY AND CONCLUSIONS

The annual increase of salinity in Lake Qarun and the decline of its fish productivity were the subject of several investigations. It is convenient for the present study to rely on salinity data collected over a long period. However, to make more solid comparison, the data were normalized to calculate the total salt content in the water of the Lake (in million tons), the salt content (in gm/l) and the corrected salinity values. It is found that, the rate of increase of salinity was very slow in the period between 250 B.C. and 1800 A.D. While between 1800 and 1900 the salinity increased slowly and then started to change rapidly afterwards.

The earlist determination of salinity of the Lake was in 1901 as 13.42 gm/l. The average salinity or dissolved salts (in gm/l) determined later has been increased from 11.1 gm/l in 1906 to 32.5‰ in 1982. The annual variation of salinity in the Lake is masked as a result of the continuous change in its level. Although the changes in salinity values in the last few decades were insignificant, the total salt content in the Lake water (in million tons) shows a progressive increase from year to year according to the amount of water discharging into the Lake. The annual rates at which the total salt content in the Lake had been increasing, are found to be 0.3×10^6 tons, 0.375×10^6 tons and 0.41×10^6 tons during (1910-1950), (1950-1970) and (1970-1982) respectively. The rate is being expected to remain unchangeable during the period 1982-2050 as the Lake water appears to stand at a constant level. Accordingly, the mean salinity of the Lake may show a progressive increase in the next few decades, which in turn may lead to the change in the Lake bottom fauna and consequently its fisheries.

A graphical representation for these data has been constructed and an emperical estimation has been investigated to predict an estimate of the total salt content for the next few decades. Moreover, the total salt content of the Lake is given at different water levels.

It is concluded that the Lake may show a progressive increase in its salinity for the next decades. Accordingly, the Lake may be converted into a dead body of water unless a certain treatment is done by removing a certain quantity of its high salinity water existing in summer for adjusting the salinity of the Lake at a desired level which is suitable for fishes to survive.

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